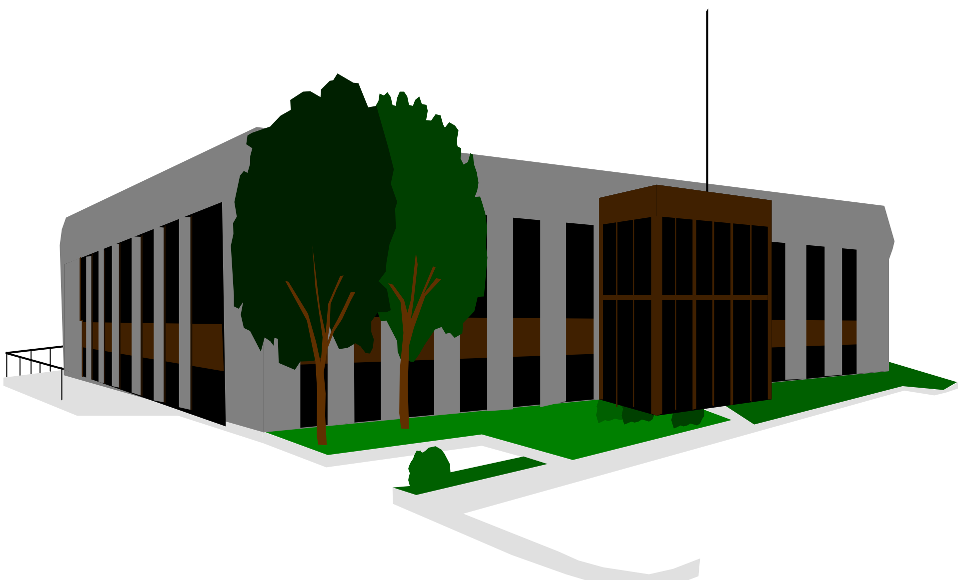
INDOOR AIR QUALITY ASSESSMENT

Joseph P. DeMello Elementary School
654 Dartmouth Street
Dartmouth, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
July, 2002

Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), was asked to provide assistance and consultation regarding indoor air quality issues and health concerns at the Joseph P. DeMello Elementary School, 654 Dartmouth Street, Dartmouth, Massachusetts.

On September 9, 2001 Cory Holmes an Environmental Analyst in the Emergency Response/Indoor Air Quality (ER/IAQ) program, conducted an indoor air quality assessment of the gymnasium. Mike Feeney, Director of BEHA's ER/IAQ Program accompanied Mr. Holmes for part of that assessment. A letter was issued containing preliminary information related to microbial growth and conditions in the gymnasium observed at that time (MDPH, 2001). The letter also gave a number of recommendations, many of which were acted upon by the Dartmouth School Department (DSD). Actions on recommendations are included as Appendix I. Mr. Holmes returned to the building on March 20, 2002 to conduct general indoor air quality testing of the building, which is the subject of this report.

The school is a single-story brick building built in 1955. An addition was constructed in 1966. A portable classroom wing was added in 1994. The school consists of general classrooms, an art room, a music room, offices, gymnasium, library and cafeteria.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school houses kindergarten through fifth grade, with a student population of approximately 540 and a staff of approximately 80. Tests were taken under normal operating conditions and results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that the carbon dioxide levels in the 1955 portion of the building were elevated above 800 ppm (parts per million) in eight of twenty-one areas surveyed, indicating ventilation problems in these areas of the school.

Fresh air in classrooms is supplied by wall-mounted unit ventilators (univents) (see Figure 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and a heating coil, and is then expelled from the univent by motorized fans through fresh air diffusers.

Univents were operating in all of the areas surveyed (see Tables). Obstructions to airflow, such as books, papers and posters on top of univents, as well as desks and carts in front of univent return vents, were seen in a number of classrooms (see Picture 1). To function as designed, univent fresh air diffusers and return vents must remain free of obstructions.

Ventilation in the gymnasium, cafeteria, interior rooms and offices is provided by air handling units (AHUs) located either in mechanical rooms or on the roof. The AHU for the cafeteria is reportedly not used due to lack of temperature control (overheating).

Exhaust vents in the 1966 addition are located in the ceilings of coat closets. Classroom air is drawn into the coat closet via an undercut below the closet door. This design allows for the vents to be easily blocked by stored materials. In a number of classrooms, these vents were blocked with books, book bags, boxes and other items. In order to function properly, these vents must remain free of obstructions. No draw was detected from the ceiling-mounted exhaust vent in the resource room near the library, which may indicate that the system was deactivated or that rooftop motors were not operating (see Picture 2).

The mechanical exhaust ventilation system in the original building consists of wall-mounted vents. A number of these vents had little or no draw of air. As with the univents, a number of exhaust vents were obstructed by various items (see Picture 3). Without sufficient exhaust ventilation, normally occurring pollutants cannot be removed allowing them to build up and lead to indoor air quality/comfort complaints.

Ventilation for the portable classroom wing is provided by two air-handling units (AHUs) located on the exterior wall of the building. Fresh air is distributed to classrooms via ductwork connected to ceiling-mounted air diffusers. The amount of fresh air drawn into the units is controlled by moveable louvers connected to an activator motor that adjusts to alter fresh air intake to maintain temperature. Return vents draw air back to the units through wall or ceiling-mounted grilles. A thermostat controls the heating, ventilating and air conditioning (HVAC) system. The thermostat has fan settings of "on" and "automatic". The thermostat was set to the "automatic" setting during the assessment (see Picture 4). The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once a preset temperature is measured by the thermostat, the HVAC system is deactivated. Therefore no mechanical ventilation is provided until the thermostat re-activates the system.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems reportedly occurred approximately four years ago. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (BOCA, 1993; SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix II.

Temperature readings ranged from 69° F to 73 ° F, which were very close to the BEHA recommended range. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. It is also difficult to control temperature and maintain comfort without operating the HVAC equipment as designed (e.g., exhaust vents off, univents obstructed).

The relative humidity in the building was below the BEHA recommended comfort range in all areas surveyed. Relative humidity measurements ranged from 21 to 34 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Of note is that relative humidity measured indoors exceeded outdoor measurements (range +1-14 percent) in all areas. The increase in relative humidity can indicate that the exhaust system is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important since the sensation of heat conditions increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperatures rise, the addition of more relative humidity will make occupants feel hotter.

If moisture is removed, the comfort of the individuals is increased. While temperature is mainly a comfort issue, relative humidity in excess of 70% can provide an environment for mold and fungal growth (ASHRAE, 1989). During periods of high relative humidity (late spring/summer months), windows and exterior doors should be closed to keep moisture out. In addition, AHUs, univents and exhaust ventilation should be activated to control moist air in the building.

Microbial/Moisture Concerns

Several classrooms had a number of plants. A hallway near the main office contains an interior garden with living plants. It could not be determined if these planters have adequate drainage. Plants can be a source of pollen and mold, which can be respiratory irritants to some individuals. Plants should be properly maintained and have adequate drainage. Plants should also be located away from the air stream of ventilation sources to prevent the aerosolization of mold, pollen or particulate matter.

Water-damaged ceiling tiles were noted in the portable classroom (see Picture 5). If wetted repeatedly, porous materials can grow mold and be a source of unpleasant odors. Water-damaged building materials should be replaced after a water leak is discovered.

Several classrooms contained humidifiers. Humidifiers/dehumidifiers should be emptied and cleaned per the manufacturer's instructions to prevent bacterial and mold growth.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. Exposed fiberglass was observed around the ductwork to the cafeteria

AHU (see Picture 6). Fiberglass can be an eye, skin and respiratory irritant to certain individuals.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed to be piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provide a source for dusts to accumulate. These items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. These items should be relocated and/or cleaned periodically to avoid excessive dust build up.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Classroom 22 contained an air purifier and a window-mounted air conditioner. This equipment is normally equipped with filters, which should be cleaned or changed per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made:

1. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.
2. Examine each AHU (e.g., cafeteria) and univent and for proper function. Survey equipment to ascertain if an adequate air supply exists for each area serviced.

Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the maintenance and calibration of HVAC equipment and univent fresh air control dampers school-wide.

3. Inspect exhaust motors and belts for proper function, repair and replace as necessary. Consider asking the HVAC engineering firm mentioned previously to examine the possibility of increasing exhaust capabilities in the original building.
4. Shorten flexible ductwork shown in Picture 2 to decrease angles and increase airflow.
5. Remove all blockages from univents and exhaust vents to facilitate airflow. Consider removing coat closet doors to prevent blockage or re-locating passive door vents to the top of coat closet doors to improve exhaust ventilation.
6. Consider having the systems re-balanced every five years by an HVAC engineering firm (SMACNA, 1994).
7. Calibrate, repair and/or replace thermostats as necessary to maintain control of comfort.
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
9. Keep plants away from univents in classrooms. Ensure plants have drip pans and examine drip pans for mold growth. Disinfect areas with an appropriate antimicrobial where necessary.

10. Consider abandoning use of hallway garden. If not, remove plants and examine the base of the planter for appropriate drainage, water leaks and microbial growth. If microbial growth is present, disinfect non-porous surfaces with an appropriate antimicrobial agent.
11. Repair any water leaks and replace any remaining water-stained or missing ceiling tiles. Examine the areas above and behind these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
12. Clean and maintain dehumidifiers as per the manufacturer's instructions.
13. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
14. Encapsulate exposed fiberglass insulation in cafeteria.
15. Clean/change filters in air purifiers and portable air conditioners as per the manufacturer's instructions.

References

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

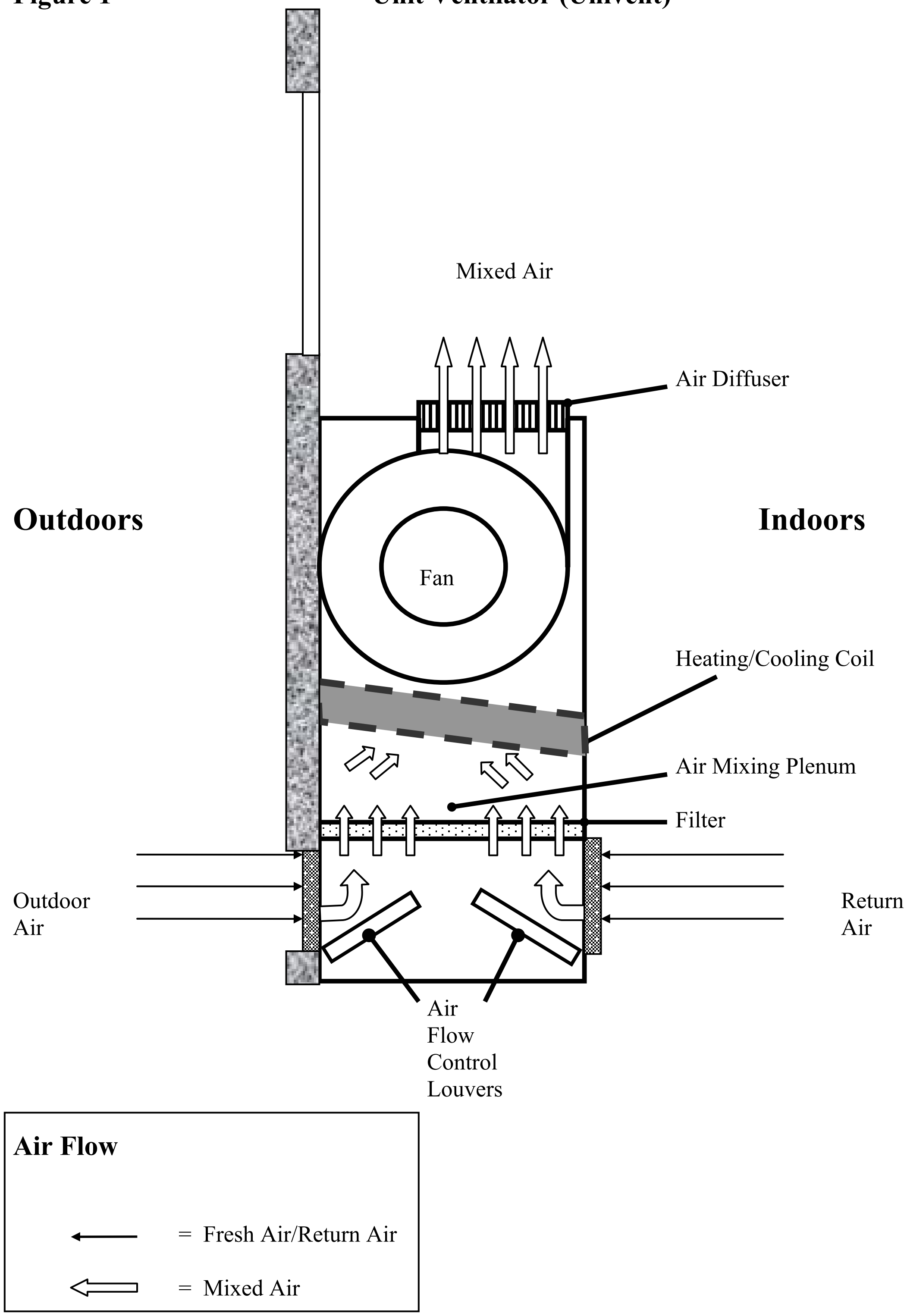
MDPH. 2001. Letter to Thomas Kelly, Superintendent Dartmouth Public Schools from Suzanne Condon, Assistant Commissioner, Bureau of Environmental Health Assessment concerning Indoor Air Quality Conditions in the gymnasium of the DeMello Elementary School, Dartmouth, MA. Massachusetts Department of Public Health, Boston, MA. Dated November 1, 2001.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

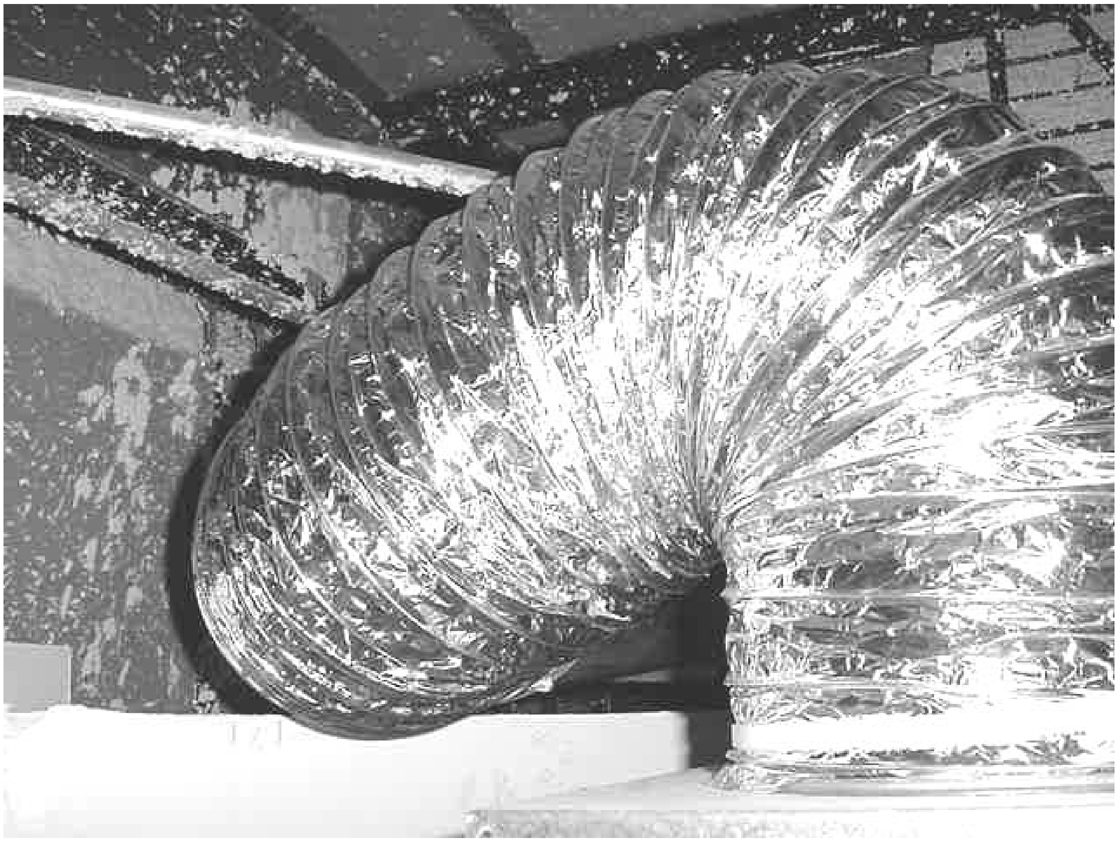
Figure 1 **Unit Ventilator (Univent)**



Picture 1

Classroom Univent Obstructed by Various Items

Picture 2



Twisted Ductwork above Ceiling in Resource Room near Library

Picture 3

Partially Blocked Exhaust Vent in Classroom

Picture 4

Portable Classroom Thermostat Fan switch to "Auto"

Picture 5

Water Damaged Ceiling Tiles in Portable Classroom

Picture 6

Exposed Fiberglass Insulation in Cafeteria (Stage Area)

TABLE 1

Indoor Air Test Results –DeMello Elementary School, Dartmouth, MA – March 20, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Outside (Background)	402	65	20					
Gym (Play Room)	736	70	21	30+	No	Yes	Yes	
Room 22	688	69	26	14	Yes	Yes	Yes	Air purifier, 2 humidifiers, window-mounted air conditioner, exhaust off (cycles)
Room 21	531	71	25	17	Yes	Yes	Yes	Items on/in front of univent
Room 20	660	72	25	19	Yes	Yes	Yes	
Hallway								Peeled up rug
Room 18	675	72	25	16	Yes	Yes	Yes	
Room 17	701	71	25	21	Yes	Yes	Yes	
Room 16	629	71	26	19	Yes	Yes	Yes	
Portable Classroom	1160	73	34	19	Yes	Yes	Yes	8 water-damaged CT, rooftop AHU, thermostat-"auto"

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results –DeMello Elementary School, Dartmouth, MA – March 20, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 1	729	72	26	0	Yes	Yes	Yes	Table in front of univent return, exhaust off
Room 6	1040	72	28	22	Yes	Yes	Yes	Items in front of univent, exhaust off, door open
Room 3	687	73	26	0	Yes	Yes	Yes	Exhaust off, door open
Room 4	1117	73	28	0	Yes	Yes	Yes	Exhaust off
Cafeteria	1080	73	29	200	Yes	Yes	Yes	2 AHUs, exposed fiberglass, AHUs not activated due to heat issues
Room 14	682	71	25	22	Yes	Yes	Yes	
Library	750	71	27	28	Yes	Yes	Yes	Exhaust vent partially obstructed, wall-mounted fans to circulate air, door open
Gifford	946	72	27	6	Yes	Yes	Yes	Air purifier, exhaust off
Room 23	748	73	25	21	Yes	Yes	Yes	Items over/on/in front of univent, exhaust off

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

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	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results –DeMello Elementary School, Dartmouth, MA – March 20, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Ms. O'Connor	633	71	27	7	Yes	Yes	Yes	Plants on univent, window and door open, humidifier, unit exhaust ventilator off
Room 11	963	70	27	1	Yes	Yes	Yes	(23) occupants gone ~20 min., exhaust weak
Room 8	1007	73	33	21	Yes	Es	Yes	Exhaust on-no draw, door open
Room 9	1422	73	32	22	Yes	Yes	Yes	Exhaust on-no draw

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Appendix 1
Joseph P. DeMello Elementary School
May 2002

Actions on Previous Recommendations

As discussed, BEHA had previously made recommendations to improve indoor air quality (MDPH, 2001). The Dartmouth School Department (DSD) and DeMello Elementary staff had implemented a number of these recommendations at the time of the second visit. These efforts should serve to help improve indoor air quality in the gymnasium. The following is a status report of action(s) on BEHA recommendations based on reports from school officials, photographs and BEHA staff observations.

1. **Remove accumulated dust from ceiling tiles, roof supports and trusses with a vacuum cleaner equipped with a high efficiency particulate arrestance (HEPA) filter.**

   Action Taken: The DSD purchased a lift to conduct a thorough cleaning and disinfection of all ceiling tiles, roof supports and trusses as verified by BEHA staff (see Picture A-1). Supports and trusses were also repainted.

2. **If possible, contact the ceiling tile manufacturer to discuss if any cleaning options/solutions are recommended.**

   Action Taken: See Action 1.

3. **Use an appropriate antimicrobial agent to clean the non-porous surface of ceiling tiles, roof supports and trusses. After disinfection, clean non-porous surfaces with ordinary soap and water.**

   Action Taken: See Action 1

4. **After disinfection is completed, vacuum all gymnasium flat surfaces with a HEPA filter vacuum cleaner to remove dislodged debris.**

   Action Taken: This advice was reportedly taken. All flat surfaces were cleaned of accumulated dirt, dust and debris at the time of the assessment.

5. **If proper cleaning and disinfection is not possible, consider replacement of all stained ceiling tiles. This measure will remove actively growing mold colonies that may be present. This work should be conducted at a time when occupants are not present in the area. Contain the area where contaminated materials are removed to prevent the spread of dust and mold spores. Once work is completed, ensure that the area is thoroughly cleaned and disinfected with an appropriate antimicrobial. Renovation generated dust and particulates in carpeted areas should be vacuumed with a HEPA filtered vacuum cleaner.**

   Action Taken: See Actions 1 & 4.

6. **Examine the areas above and behind these areas for water damaged building materials and microbial growth. If additional water damaged building materials are colonized with microbial growth, remove. Disinfect areas of water leaks/microbial growth with an appropriate antimicrobial.**

   Action Taken: This advice was reportedly taken. No visible water damaged building materials, ceiling tiles or microbial growth was observed by BEHA staff.

7. **Consider contacting a mechanical engineering firm to discuss options to increase air circulation by the gymnasium AHU. Repair or replacement may be necessary.**

Action Taken: Mechanical components for the gymnasium ventilation system were reportedly repaired/replaced thereby greatly increasing air circulation (see Picture A-2).

8. **Consider installing an exhaust fan in skylight furthest from the gymnasium AHU to increase air circulation and remove excess moisture. Care should be taken to ensure the fan is watertight (e.g., proper flashing sealing compound) to prevent leakage.**

   Action Taken: This Action was not conducted; however air circulation was increased by Action 7.

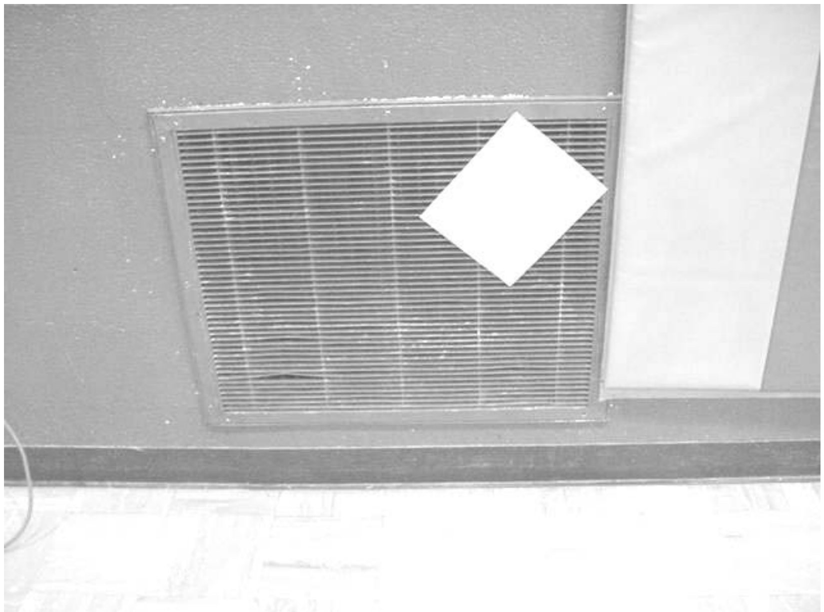
Appendix 1
Joseph P. DeMello Elementary School
May 2002

Picture 1

Gymnasium Ceiling and Support Trusses free of Accumulated Dust and Debris

Appendix 1
Joseph P. DeMello Elementary School
May 2002

Picture 2



Return Vent for Gymnasium AHU, Exhaust Ventilation Capacity Greatly Increased, Note Paper Being Drawn Into Vent